

Trees, treelets and shrubs of white-sand “campinarana” vegetation

Layon Oreste Demarchi¹, Daniel Praia Portela de Aguiar², Viviane Pagnussat Klein¹, Florian Wittmann^{1,3} & Maria Teresa Fernandez Piedade¹¹Instituto Nacional de Pesquisas da Amazônia (INPA), Pós-Graduação em Botânica, Brasil; ²Ministério Público do Estado do Amazonas, Brasil;³Karlsruhe Institute for Technology (KIT), Rastatt, Germany.

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1 *Tapirira guianensis*
ANACARDIACEAE
D. de Aguiar2 *Tapirira guianensis*
ANACARDIACEAE
D. de Aguiar3 *Annona angustifolia*
ANNONACEAE4 *Annona angustifolia*
ANNONACEAE5 *Guatteria cf. duckeana*
ANNONACEAE6 *Guatteria cf. duckeana*
ANNONACEAE7 *Guatteria schomburgkiana*
ANNONACEAE8 *Guatteria schomburgkiana*
ANNONACEAE9 *Tetrameranthus duckei*
ANNONACEAE10 *Xylopia spruceana*
ANNONACEAE11 *Xylopia spruceana*
ANNONACEAE12 *Couma utilis*
APOCYNACEAE13 *Galactophora crassifolia*
APOCYNACEAE14 *Galactophora crassifolia*
APOCYNACEAE15 *Lacistema arborescens*
APOCYNACEAE16 *Lacistema arborescens*
APOCYNACEAE17 *Lacistema gracilis*
APOCYNACEAE18 *Macoubea sprucei*
APOCYNACEAE19 *Macoubea sprucei*
APOCYNACEAE20 *Macoubea sprucei*
APOCYNACEAE

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21 *Macoubea sprucei*
APOCYNACEAE22 *Tabernaemontana flavicans*
APOCYNACEAE23 *Tabernaemontana flavicans*
APOCYNACEAE24 *Chaunochiton angustifolium*
APTANDRACEAE25 *Chaunochiton angustifolium*
APTANDRACEAE26 *Chaunochiton angustifolium*
APTANDRACEAE27 *Ilex divaricata*
AQUIFOLIACEAE28 *Ilex divaricata*
AQUIFOLIACEAE29 *Ilex divaricata*
AQUIFOLIACEAE30 *Attalea microcarpa*
ARECACEAE31 *Bactris simplicifrons*
ARECACEAE32 *Bactris simplicifrons*
ARECACEAE33 *Euterpe catinga*
ARECACEAE34 *Euterpe catinga*
ARECACEAE35 *Iriartella setigera*
ARECACEAE36 *Mauritia carana*
ARECACEAE37 *Mauritia carana*
ARECACEAE38 *Mauritiella armata*
ARECACEAE39 *Oenocarpus minor*
ARECACEAE40 *Oenocarpus minor*
ARECACEAE

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41 *Gongylolepis martiana*
ASTERACEAE42 *Gongylolepis martiana*
ASTERACEAE43 *Gongylolepis martiana*
ASTERACEAE44 *Lepidaploa arenaria*
ASTERACEAE45 *Lepidaploa arenaria*
ASTERACEAE46 *Lepidaploa arenaria*
ASTERACEAE47 *Protium altsonii*
BURSERACEAE48 *Protium heptaphyllum*
BURSERACEAE49 *Protium heptaphyllum*
BURSERACEAE50 *Protium heptaphyllum*
BURSERACEAE51 *Protium llanorum*
BURSERACEAE52 *Protium llanorum*
BURSERACEAE53 *Protium llanorum*
BURSERACEAE54 *Protium paniculatum*
BURSERACEAE55 *Protium paniculatum*
BURSERACEAE56 *Protium paniculatum*
BURSERACEAE57 *Protium paniculatum*
BURSERACEAE58 *Calophyllum cf. pachyphyllum*
CALOPHYLLACEAE59 *Gaussia parillo*
CHYSOBALANACEAE60 *Gaussia racemosa*
CHYSOBALANACEAE

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61 *Gaulettia racemosa*
CHYSOBALANACEAE62 *Hirtella racemosa*
CHYSOBALANACEAE63 *Hirtella racemosa*
CHYSOBALANACEAE64 *Hymenopus laevigatus*
CHYSOBALANACEAE65 *Hymenopus laevigatus*
CHYSOBALANACEAE66 *Hymenopus laevigatus*
CHYSOBALANACEAE67 *Hymenopus oblongifolius*
CHYSOBALANACEAE68 *Hymenopus oblongifolius*
CHYSOBALANACEAE69 *Hymenopus prismatocarpus*
CHYSOBALANACEAE70 *Hymenopus prismatocarpus*
CHYSOBALANACEAE71 *Hymenopus reticulatus*
CHYSOBALANACEAE72 *Leptobalanus latus*
CHYSOBALANACEAE73 *Leptobalanus latus*
CHYSOBALANACEAE74 *Licania hypoleuca*
CHYSOBALANACEAE75 *Clusia insignis*
CLUSIACEAE76 *Clusia nascimentojuniorii*
CLUSIACEAE77 *Clusia nascimentojuniorii*
CLUSIACEAE78 *Clusia nascimentojuniorii*
CLUSIACEAE79 *Clusia nemorosa*
CLUSIACEAE80 *Clusia nemorosa*
CLUSIACEAE

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81 *Clusia nemorosa*
CLUSIACEAE82 *Clusia nemorosa*
CLUSIACEAE83 *Tovomita calophyllophylla*
CLUSIACEAE84 *Tovomita calophyllophylla*
CLUSIACEAE85 *Tovomita calophyllophylla*
CLUSIACEAE86 *Tovomita cornuta*
CLUSIACEAE87 *Tovomita cornuta*
CLUSIACEAE88 *Tovomita cornuta*
CLUSIACEAE89 *Tovomita cornuta*
CLUSIACEAE90 *Tovomita cornuta*
CLUSIACEAE91 *Terminalia macrophylla*
COMBRETACEAE92 *Terminalia macrophylla*
COMBRETACEAE93 *Sloanea duckei*
ELAECARPACEAE94 *Sloanea duckei*
ELAECARPACEAE95 *Erythroxylum campinense*
ERYTHROXYLACEAE96 *Alchornea discolor*
EUPHORBIACEAE97 *Croton dissectistipulatus*
EUPHORBIACEAE98 *Croton dissectistipulatus*
EUPHORBIACEAE99 *Croton dissectistipulatus*
EUPHORBIACEAE100 *Hevea rigidifolia*
EUPHORBIACEAE

D. de Aguiar

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101 *Hevea rigidifolia*
EUPHORBIACEAE102 *Hevea rigidifolia*
EUPHORBIACEAE103 *Mabea uleana*
EUPHORBIACEAE104 *Mabea uleana*
EUPHORBIACEAE105 *Aldina heterophylla*
FABACEAE
D. de Aguiar106 *Aldina heterophylla*
FABACEAE107 *Aldina heterophylla*
FABACEAE108 *Chamaecrista adiantifolia*
FABACEAE109 *Chamaecrista adiantifolia*
FABACEAE110 *Chamaecrista adiantifolia*
FABACEAE111 *Dimorphandra campinarum*
FABACEAE112 *Dimorphandra campinarum*
FABACEAE113 *Dimorphandra campinarum*
FABACEAE114 *Dimorphandra pennigera*
FABACEAE115 *Dimorphandra pennigera*
FABACEAE116 *Eperua glabriflora*
FABACEAE

D. de Aguiar

117 *Eperua glabriflora*
FABACEAE

D. de Aguiar

118 *Inga paraensis*
FABACEAE

D. de Aguiar

119 *Macrolobium duckeianum*
FABACEAE120 *Macrolobium duckeianum*
FABACEAE

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121 *Macrolobium duckeanum*
FABACEAE122 *Macrolobium gracile*
FABACEAE123 *Macrolobium huberianum*
FABACEAE124 *Macrolobium huberianum*
FABACEAE125 *Macrolobium punctatum*
FABACEAE126 *Macrolobium punctatum*
FABACEAE127 *Macrosamanea pubiramea*
FABACEAE128 *Ormosia discolor*
FABACEAE129 *Ormosia trifoliolata*
FABACEAE130 *Ormosia trifoliolata*
FABACEAE
D. de Aguiar131 *Ormosia trifoliolata*
FABACEAE132 *Parkia aff. igneiflora*
FABACEAE133 *Parkia igneiflora*
FABACEAE134 *Parkia igneiflora*
FABACEAE135 *Parkia panurensis*
FABACEAE136 *Parkia panurensis*
FABACEAE137 *Swartzia brachyrachis*
FABACEAE138 *Swartzia brachyrachis*
FABACEAE139 *Swartzia brachyrachis*
FABACEAE140 *Swartzia polypylla*
FABACEAE

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141 *Swartzia polyphylla*
FABACEAE142 *Potalia amara*
GENTIANACEAE143 *Potalia amara*
GENTIANACEAE144 *Humiria balsamifera*
HUMIRIACEAE145 *Humiria balsamifera*
HUMIRIACEAE146 *Humiria balsamifera*
HUMIRIACEAE147 *Humiria balsamifera*
HUMIRIACEAE148 *Sacoglottis guianensis*
HUMIRIACEAE149 *Sacoglottis guianensis*
HUMIRIACEAE150 *Sacoglottis mattogrossensis*
HUMIRIACEAE151 *Vitex duckei*
LAMIACEAE152 *Vitex duckei*
LAMIACEAE153 *Endlicheria arenosa*
LAURACEAE154 *Endlicheria arenosa*
LAURACEAE155 *Endlicheria arenosa*
LAURACEAE156 *Ocotea debilis*
LAURACEAE157 *Hebepepalum humiriifolium*
LINACEAE158 *Acmanneria minima*
MALPIGHIACEAE159 *Acmanneria minima*
MALPIGHIACEAE160 *Acmanneria minima*
MALPIGHIACEAE

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161 *Byrsinima laevis*
MALPIGHIACEAE162 *Byrsinima laevis*
MALPIGHIACEAE163 *Heteropterys orinocensis*
MALPIGHIACEAE164 *Heteropterys orinocensis*
MALPIGHIACEAE165 *Catostemma sclerophyllum*
MALVACEAE166 *Catostemma sclerophyllum*
MALVACEAE167 *Pachira faroensis*
MALVACEAE168 *Pachira faroensis*
MALVACEAE169 *Pachira faroensis*
MALVACEAE170 *Henriettea granulata*
MELASTOMATACEAE171 *Henriettea granulata*
MELASTOMATACEAE172 *Henriettea granulata*
MELASTOMATACEAE173 *Henriettea maroniensis*
MELASTOMATACEAE174 *Henriettea maroniensis*
MELASTOMATACEAE175 *Macairea theresiae*
MELASTOMATACEAE176 *Macairea theresiae*
MELASTOMATACEAE177 *Miconia waimiri-atroari*
MELASTOMATACEAE178 *Miconia waimiri-atroari*
MELASTOMATACEAE179 *Miconia gratissima*
MELASTOMATACEAE180 *Miconia gratissima*
MELASTOMATACEAE

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181 *Miconia subsimplex*
MELASTOMATACEAE182 *Mouriri nervosa*
MELASTOMATACEAE183 *Mouriri nervosa*
MELASTOMATACEAE184 *Sandemania hoehnei*
MELASTOMATACEAE185 *Sandemania hoehnei*
MELASTOMATACEAE186 *Tococa macrosperma*
MELASTOMATACEAE187 *Tococa macrosperma*
MELASTOMATACEAE188 *Emmotum orbiculatum*
METTENIUSACEAE189 *Emmotum orbiculatum*
METTENIUSACEAE190 *Iryanthera laevis*
MYRISTICACEAE191 *Iryanthera laevis*
METTENIUSACEAE192 *Eugenia biflora*
MYRTACEAE193 *Myrcia citrifolia*
MYRTACEAE194 *Myrcia citrifolia*
MYRTACEAE195 *Myrcia servata*
MYRTACEAE196 *Neea obovata*
NYCTAGINACEAE197 *Neea obovata*
NYCTAGINACEAE198 *Neea obovata*
NYCTAGINACEAE199 *Neea obovata*
NYCTAGINACEAE200 *Dulacia candida*
OLACACEAE

Trees, treelets and shrubs of white-sand “campinarana” vegetation

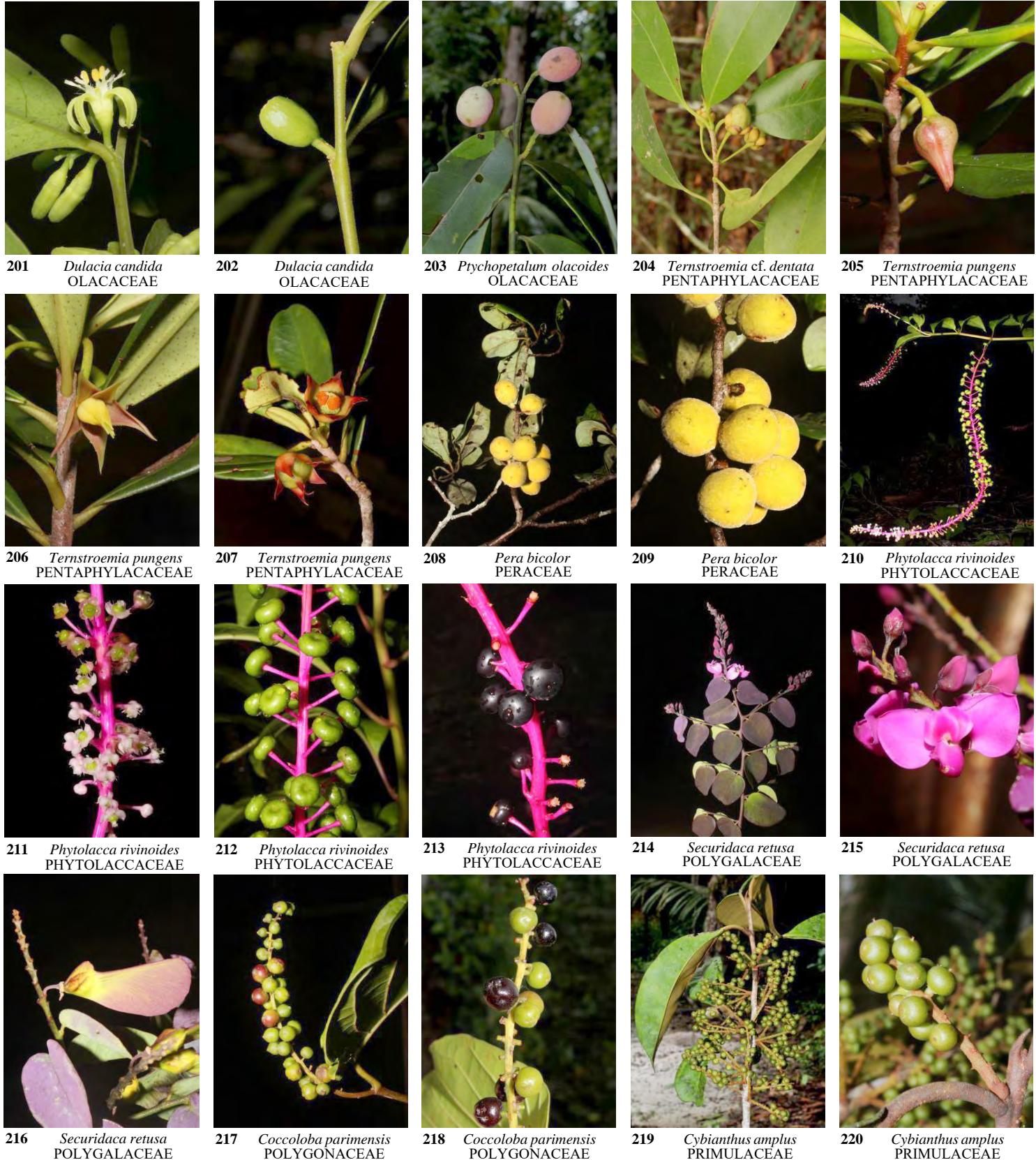
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221 *Cybianthus fulvopulverulentus*
PRIMULACEAE222 *Cybianthus fulvopulverulentus*
PRIMULACEAE223 *Cybianthus aff. fulvopulverulentus*
PRIMULACEAE224 *Cybianthus aff. fulvopulverulentus*
PRIMULACEAE225 *Cybianthus reticulatus*
PRIMULACEAE226 *Cybianthus reticulatus*
PRIMULACEAE227 *Cybianthus reticulatus*
PRIMULACEAE228 *Rhabdodendron macrophyllum*
RHABDODENDRACEAE229 *Rhabdodendron macrophyllum*
RHABDODENDRACEAE230 *Sterigmapetalum plumbeum*
RHIZOPHORACEAE231 *Sterigmapetalum plumbeum*
RHIZOPHORACEAE232 *Calycophyllum obovatum*
RUBIACEAE234 *Duroia saccifera*
RUBIACEAE235 *Duroia saccifera*
RUBIACEAE236 *Ferdinandusa guainiae*
RUBIACEAE237 *Ferdinandusa guainiae*
RUBIACEAE238 *Ferdinandusa guainiae*
RUBIACEAE239 *Ixora intensa*
RUBIACEAE240 *Ixora intensa*
RUBIACEAE

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241 *Ixora intensa*
RUBIACEAE242 *Kutchubaea oocarpa*
RUBIACEAE243 *Kutchubaea oocarpa*
RUBIACEAE244 *Kutchubaea oocarpa*
RUBIACEAE245 *Kutchubaea sericantha*
RUBIACEAE246 *Pagamea coriacea*
RUBIACEAE247 *Pagamea coriacea*
RUBIACEAE248 *Pagamea coriacea*
RUBIACEAE249 *Pagamea coriacea*
RUBIACEAE250 *Pagamea coriacea*
RUBIACEAE251 *Palicourea blakei*
RUBIACEAE252 *Palicourea blakei*
RUBIACEAE253 *Palicourea hoffmannseggiana*
RUBIACEAE254 *Palicourea hoffmannseggiana*
RUBIACEAE255 *Palicourea hoffmannseggiana*
RUBIACEAE256 *Palicourea hoffmannseggiana*
RUBIACEAE257 *Palicourea huberi*
RUBIACEAE258 *Palicourea huberi*
RUBIACEAE259 *Palicourea huberi*
RUBIACEAE260 *Palicourea nitidella*
RUBIACEAE

Trees, treelets and shrubs of white-sand “campinarana” vegetation

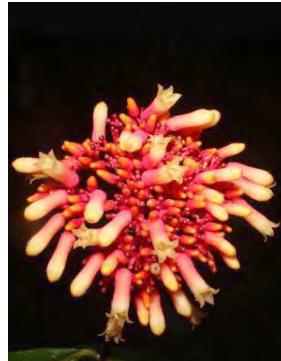
Layon Oreste Demarchi¹, Daniel Praia Portela de Aguiar², Viviane Pagnussat Klein¹, Florian Wittmann^{1,3} & Maria Teresa Fernandez Piedade¹¹Instituto Nacional de Pesquisas da Amazônia (INPA), Pós-Graduação em Botânica, Brasil; ²Ministério Público do Estado do Amazonas, Brasil;³Karlsruhe Institute for Technology (KIT), Rastatt, Germany.

Photos: L. O. Demarchi [layon.lod@gmail.com]. Produced by the authors. Support: CNPq fellowship, program PELD – MAUA (MCTIC/CNPq/FAPs-GN: 441590/2016-0). Acknowledgment: Amazonas Environmental State Secretary (SEMA), and the Amazon Tall Tower Observatory (ATTO).

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261 *Palicourea nitidella*
RUBIACEAE262 *Palicourea nitidella*
RUBIACEAE263 *Palicourea nitidella*
RUBIACEAE264 *Remijia amazonica*
RUBIACEAE265 *Remijia amazonica*
RUBIACEAE266 *Remijia hirsuta*
RUBIACEAE267 *Remijia hirsuta*
RUBIACEAE268 *Remijia hirsuta*
RUBIACEAE269 *Remijia hirsuta*
RUBIACEAE270 *Remijia hirsuta*
RUBIACEAE271 *Remijia morilloi*
RUBIACEAE272 *Remijia morilloi*
RUBIACEAE273 *Remijia morilloi*
RUBIACEAE274 *Retiniphyllum chloranthum*
RUBIACEAE275 *Retiniphyllum schomburgkii*
RUBIACEAE276 *Retiniphyllum schomburgkii*
RUBIACEAE277 *Retiniphyllum schomburgkii*
RUBIACEAE278 *Adiscanthus fusciflorus*
RUTACEAE279 *Adiscanthus fusciflorus*
RUTACEAE280 *Adiscanthus fusciflorus*
RUTACEAE

Trees, treelets and shrubs of white-sand “campinarana” vegetation

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281 *Hortia longifolia*
RUTACEAE282 *Hortia longifolia*
RUTACEAE283 *Hortia longifolia*
RUTACEAE284 *Hortia longifolia*
RUTACEAE285 *Matayba inelegans*
SAPINDACEAE286 *Matayba inelegans*
SAPINDACEAE287 *Matayba inelegans*
SAPINDACEAE288 *Matayba opaca*
SAPINDACEAE289 *Matayba opaca*
SAPINDACEAE290 *Matayba opaca*
SAPINDACEAE
D. de Aguiar291 *Matayba opaca*
SAPINDACEAE292 *Talisia ghilleiana*
SAPINDACEAE293 *Talisia ghilleiana*
SAPINDACEAE294 *Talisia ghilleiana*
SAPINDACEAE295 *Chrysophyllum sanguinolentum*
SAPOTACEAE296 *Chrysophyllum sanguinolentum*
SAPOTACEAE297 *Chrysophyllum sanguinolentum*
SAPOTACEAE298 *Elaeoluma cf. glabrescens*
SAPOTACEAE299 *Elaeoluma cf. glabrescens*
SAPOTACEAE300 *Elaeoluma schomburgkiana*
SAPOTACEAE

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301 *Elaeoluma schomburgkiana*
SAPOTACEAE



302 *Manilkara bidentata*
SAPOTACEAE



303 *Manilkara bidentata*
SAPOTACEAE



304 *Manilkara bidentata*
SAPOTACEAE



305 *Pouteria cuspidata*
SAPOTACEAE



306 *Pouteria cuspidata*
SAPOTACEAE



307 *Pouteria scrobiculata*
SAPOTACEAE



308 *Pouteria scrobiculata*
SAPOTACEAE



309 *Pradosia schomburgkiana*
SAPOTACEAE



310 *Pradosia schomburgkiana*
SAPOTACEAE



311 *Pradosia schomburgkiana*
SAPOTACEAE



312 *Pradosia schomburgkiana*
SAPOTACEAE



313 *Simaba guianensis*
SIMAROUBACEAE



314 *Simaba guianensis*
SIMAROUBACEAE



315 *Simaba guianensis*
SIMAROUBACEAE



316 *Simarouba amara*
SIMAROUBACEAE



317 *Ruizterania retusa*
VOCHysiACEAE



318 *Ruizterania retusa*
VOCHysiACEAE

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The white-sand “campinaranas” of the Uatumã SDR are composed of different shrub- and forest formations that occur as fragmented “islands” surrounded by upland (*terra-firme*) forest. There are striking structural and floristic differences between the different *campinarana* vegetation formations, but they share the sandy and very nutrient-poor soils. Sandy soils often have an underlying hardpan that causes surface flooding through high groundwater levels during the rainy season. *Campinaranas* are relatively open forest formations, where high incidence of solar radiation combined with the low water retention capacity of sandy soils subject plants to seasonal drought during the dry season. *Campinara* plants need a series of adaptations to cope with these environmental stressors. Although relatively species poor when compared to the surrounding *terra-firme*, *campinaranas* are (therefore) composed of many specialized and endemic taxa.

Campinarana vegetation formations



319 Open shrub physiognomy / *campina* or *campinarana arbustiva*



320 Highly dense forested physiognomy / *paliteiro* or *campinarana arborizada*



321 Forested physiognomy with high groundwater level / *campinarana florestada* or *chavascal*



322 Forested physiognomy in transition to *terra-firme* / *campinarana florestada*

Special thanks to the taxonomists who helped with identification in specific families: Maria de Fátima Freitas (Primulaceae); Charlotte Taylor (Rubiaceae); Maihyra Marina Pombo (Annonaceae); Anderson Alves-Araújo (Sapotaceae); Renato Goldenberg (Melastomataceae); Guilherme Sousa (Fabaceae); Mike Hopkins (Fabaceae); Ana Sofia Sousa de Holanda (Humiriaceae); Fernanda Cabral (Clusiaceae); Lucas Cardoso Marinho (Clusiaceae); Magno Luis Vasques Pilco (Burseraceae). Thanks also to parataxonomo José Ferreira Ramos and technicians from INPA: Mariana Mesquita, Valdeney Araújo, Elizabeth Rodrigues Rebouças, Celso Rabelo Costa. The ATTO project team for logistics and field support: Nagib Alberto Souza, Amauri Rodriguês, Antonio Huxley do Nascimento, André Matos, Wallace Rabelo Costa, and the people who helped in the field: Gildo Oliveira Feitoza, Maria Julia Ferreira, Gabriel Caldas, Natalia Kinap, Jeisiane Santos da Silva, Gilvan da Silva Costa, William Bercê.